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Enhancing 911 Systems A Usability Test Plan

Beth Ellington
University of North Carolina at Chapel Hill

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Beth Ellington
The University of North Carolina at Chapel Hill
elliv@email.unc.edu

ABSTRACT

This study is the development of a usability test plan for implementation of an Enhanced 911 Computer Aided Dispatch (CAD) system by emergency response dispatch centers. Enhanced 911 system technologies will allow emergency response personnel to locate cellular 911 callers in distress by pinpointing the latitude and longitude of their location, and mapping it through the use of a Geographic Information System (GIS). This usability test plan has been developed through research within a dispatch center to ensure that the dispatchers, who receive the 911 calls and dispatch the appropriate emergency response personnel, are receptive to the new technology, and the new interface with the GIS capability does not impede their ability to assistance callers. Through this usability test plan the dispatchers will be involved in the entire process to integrate an additional window into the CAD screen that contains a GIS map to optimize the usability of the emergency response system. After analysis of the usability test results the emergency response dispatch center personnel will be able to develop methods to enhance the operational efficiency of the emergency response dispatch system allowing for a seamless integration of the new Enhanced 911 CAD/GIS system components.

Keywords

Enhanced 911, emergency response systems, usability testing, computer-aided dispatch systems.

INTRODUCTION

Problem Definition

When 911 calls are made from cellular phones the technological limitations may not route the call, via the cell tower and land-based telephone company lines, to the nearest dispatch center. The dispatcher does not receive the location of the caller on his or her computer screen. This could present a life-threatening situation for the caller due to lost response time. If cellular callers are unable to communicate, or do not know their exact location, the dispatcher cannot get them the assistance needed which could lose precious minutes and possibly increase fatalities. This has created a gap or void in the national emergency response system which can cause an anomalous state of knowledge (ASK) for the dispatcher (Belkin, 1980). An ASK occurs when the failure for information retrieval lies in the system being used to obtain the information and not on the user, which in this case results in the dispatcher only partially receiving the information needed to complete the task of dispatching emergency response personnel to a specific location.

It is estimated, of the 150 million calls that were made to 911 in 2000, thirty-percent were made by cellular callers. It is projected that by 2005, the majority of 911 calls will be from cellular callers (Cellular Telecommunications & Internet Association, 2003). As a result of this influx of cellular calls to 911, the inability of 911 dispatchers to locate cellular callers in distress is becoming a critical public safety issue that should be immediately addressed.

To eliminate the ASK experienced by the dispatcher, the system needs to have the capability of pinpointing the location of the cellular 911 caller. The solution seems to be simple. If the location of the cell tower, height of the receiving device on the tower, the direction from which the call is being received, and the speed of the call being received are all known you should be able to use the Pythagorean theorem, $a^2 + b^2 = c^2$, to find the latitude and longitude of the caller. (fig.1) However when there are multiple land-based phone companies and multiple cellular phone companies who all use different technologies that must be integrated the problem of implementation of the new system becomes extremely difficult and is distinct for each dispatch center. The problem is further compounded by the present Database Management System (DBMS) and CAD

systems that have been implemented at the dispatcher centers, which would incur both tangible costs of new systems and training along with the intangible costs of the familiarity of hardware and software use, the relationships with the vendors and the knowledge of support personnel if the entire systems were replaced. The solution is to design the optimum integration of the GIS component with the DBMS and CAD systems currently used by the individual dispatch centers.

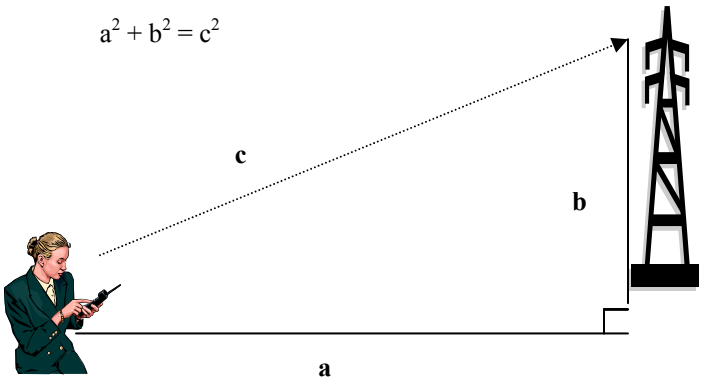

Figure 1

Background

In 1996 the Federal Communications Commission (FCC), realizing that the gap existed in the critical information that dispatch centers needed to locate cellular callers, issued a set of rules originally developed in 1994, defining how the cellular phone companies would implement a deployment schedule to fill the gap in two phases. This ruling was CC Docket No. 94-102, mandating the Enhanced 911 system to be implemented for every cellular phone company within the United States (Federal Communications Commission, 1994). The first phase of Enhanced 911 mandated that the cellular phone companies provide the phone number of the cellular phone and the location of the cell tower from which the call was being transmitted to the land-based telephone company line. Phase I implementation began in October 2001 and continues to be implemented nationally particularly in the more rural regions of the United States where the smaller regional cellular phone companies are the wireless carriers (Hatfield, 2002).

To implement the second phase of Enhanced 911 the cellular phone companies must provide the dispatch centers with the longitude and latitude of the cellular caller's location in addition to the above Phase I requirements of the cellular phone number and cell tower location. Phase II should be completed and implemented in every dispatch center in the United States by December 2005.

A mandate was issued by the FCC that a mechanism to recover the costs of facilities and equipment necessary to receive and utilize the Enhanced 911 Phase I and Phase II elements be put into place by each, and a surcharge was allowed to be added to every monthly cellular phone bill in the United States, and collected by state governments (Federal Communications Commission, 1994). These funds are dispersed, in accordance with the individual state laws and guidelines established, to the dispatch centers and the cellular phone companies when requested to purchase the technology needed for full implementation of Enhanced 911 systems.

CURRENT COMPUTER AIDED DISPATCH SYSTEM AND ENHANCED 911 PHASE I SHORTCOMINGS

The typical dispatch center utilizes a CAD system, consisting of two computer screens and a call receiving system that displays the telephone number and address of a land-based telephone call received, and the cell tower location and telephone number for a cellular call received on an additional screen. The typical dispatcher asks the caller a series of questions from a script, to determine the type of call, either emergency or non-emergency, and after determining the caller's location dispatches public safety personnel to the caller's location. The information, and the conversation are stored through a link to a DBMS that records every 911 call, and any required data for the call. The dispatcher can determine in a few seconds the type of emergency, assistance needed, and location of the caller, unless they are calling from a cellular phone and do not know their location. It takes longer to dispatch assistance to a cellular 911 caller simply because the location of the caller does not appear on the screen as they do when a land-based call is received. The Phase I location information that the dispatcher is typically receiving at present, is the location of the cell tower that transmitted the cellular call, resulting in an ASK that must be overcome by the dispatcher. This forces the dispatcher to ask several additional questions to hopefully pinpoint the exact location of the caller in order to dispatch public safety personnel.

In the case of fire, natural disaster, or major traffic accidents, when the exact location of the cellular caller cannot be verified by any other means, the dispatchers may attempt to overcome the inadequacies of the system by taking additional 911 calls until someone calls that can pinpoint the location of the person(s) in distress. This can create an information overload situation for the dispatcher that amplifies the problem of multi-tasking experienced by the dispatcher (Hiltz & Turoff, 1985). In the case of stranded motorists, or someone who has been abducted, this multiple call method is usually not an option. The dilemma that exists is most cellular phone users are not aware of the fact that the dispatcher cannot pinpoint their location. Due to the inadequacies that exist with the present Phase I Enhanced 911 system, the best advice for a caller that is unaware of their exact location is to find a pay phone, call 911, and do not leave that location until help has arrived.

In order to overcome the inadequacies in the Phase I Enhanced 911 system, the dispatch center must purchase software and hardware to make the system Phase II compatible. It is the responsibility of every dispatch center to analyze and improve their current CAD system to receive the location information from the cellular carriers via the land-based company lines, and locate the callers through the use of a GIS map. This will involve purchasing and integrating a GIS with the DBMS and CAD systems. Once the Enhanced 911 system is fully operational, the emergency response dispatch center is considered Enhanced 911 Phase II compliant by the FCC but that does not mean the newly integrated system is successful in assisting the completion of the dispatchers' critical tasks. The functionality and operability of the system should then be analyzed to see if it actually supports the users' tasks through a usability testing procedure (Jordan, 1998).

LITERATURE REVIEW

Technology may be dispersed within an organization in two ways, by being diffused or widespread throughout the organization, or by being infused or deeply integrated into a particular area of the organization (Sahay & Robey, 1996). Both technology diffusion and infusion effect the efficient operation of the dispatch center. The organization utilizes information technology in all of its departments, however the technology is deeply infused in the dispatch center, and the efficient use of technology can mean the difference between a life or death situation. The Technology Acceptance Model (TAM) describes the factors that lead to a higher acceptance and use of the new technology within an organization (Kwon & Chidambaram, 2000). Those factors include the usefulness of the technology, the ease of use of the technology, and the quality of the information system as perceived by the users, in addition to the degree to which the organization supports the use of the technology.

The use of GIS within government organizations indicates that GIS has the potential to consolidate many resources by providing a spatial analysis of data (Ventura, 1995). GIS does this by creating new work procedures related to spatial analysis of data. By using GIS to represent the location of 911 cellular callers, the dispatchers should be able to visualize their location, and dispatch assistance more efficiently. The dispatch center has chosen to integrate a GIS component with their DBMS and CAD systems. In order to maintain their current efficiency, productivity and effectiveness in dispatching assistance to all 911 callers, the integration of the GIS must be as seamless as possible.

Studies have shown that incorporating GIS with other systems does indeed give employees more information, which increases trust between departments, thus the implementation of the CAD/GIS system should force the Fire Departments, Law Enforcement Agencies, and Emergency Medical Services to develop a trust between their employees and the dispatchers, due to the distribution of more detailed information. Since the GIS/CAD system is a continuation of the current Enhanced 911 Phase I system, it should be viewed by the users as "competence-enhancing", which research has shown builds upon a base of knowledge, which enhances technology diffusion, infusion and acceptance (Robey & Sahay, 1996). With the Enhanced 911 Phase II compliant systems it is imperative that the CAD/GIS interface does not have an adverse effect on the

dispatchers and their ability to perform their task of locating callers and dispatching assistance. This is done through understanding the social processes within the dispatch center to better evaluate whether the new system will impede the process and be utilized to enhance the ability to dispatch assistance. Hopefully, the societal social consequences of not being able to assistance cellular callers in distress should motivate the adoption of the new technology within the organization, and overcome any negative effects by facilitating the meshing of the technology with the dispatch center's mission and strategic objectives.

This is reinforced through the manner in which the organization handles the processes regarding the implementation of the new technology. These processes include the initiation of the new technology, the transition to the new technology, the deployment of the new technology, the spreading of knowledge concerning the new technology, and the consequences of the new technology (Kwon & Chidambaram, 2000). How these processes are performed during the new technology introduction has a direct effect upon the success of the adoption of the technology and the implementation process. The dispatch center management personnel need to realize that the understanding of new technologies may be different for each dispatcher. These understandings effect the social interpretation that exists within an organization that influences the understanding of the implementation and consequences of the system.

In order to better evaluate the positive and negative effects of technology within the dispatch center, a usability test of the interface will be performed. Usability testing will be performed on the CAD/GIS interface with actual users of the system. The usability testing will allow the users to take ownership of a portion of the CAD/GIS interface design in order to empower them to accept, adopt and utilize the technology, and support the task of assisting cellular callers in distress. With the inclusion of employees in the usability testing, and the integration of GIS with the CAD system, the new system should mesh relevance with user satisfaction, which studies show when a direct correlation between the two exists, results in increased user satisfaction (Gluck, 1996). The dispatchers currently receive only the transmitting tower location of the cellular call. This information is irrelevant because they cannot use it to send assistance to the caller. The new system will display the longitude and latitude of the caller, and map it for a visual representation with the GIS software. The information then becomes relevant because it is transposed into relevant information by the system, thus increasing the user's satisfaction with the system (Gluck, 1996).

Research studies using GIS in local government agencies have indicated that organizations must determine if the GIS will provide better information. This can be achieved by determining which system to use, based on the criteria of which system is faster, cheaper, more reliable, more precise, more available, and more understandable (Ventura, 1995). GIS has been shown to provide better information, and enhance decision making, when the decision to utilize and implement GIS is supported by the users (Sahay & Robey, 1996). In this study, Sahay and Robey demonstrated that the barriers to the use of GIS are usually attributed to organizational behavior problems, which can be overcome, and not problems with the system. These barriers to technology use can be resolved if proper training occurs prior to implementation of the GIS. You must first understand how GIS is used in the decision making process within an organization to overcome the barriers to implementation. The dispatch center is adopting the technology because the FCC has mandated the Enhanced 911 Phase II compliance. However, this technology will greatly enhance the dispatcher's ability to answer larger volumes of 911 calls and handle the 911 calling capacity in less time. GIS has proven that it can improve decision making by local government employees, but it must overcome the organizational impediments, and understand that the majority of the benefits of the system will be intangible. This is because it is difficult to quantify the detrimental consequences of the decisions made with the Enhanced 911 GIS system unless there is a fatality or a major incident. There is no way to duplicate this in a laboratory. However, there is no debate within the organization concerning the validity of implementing the CAD/GIS system to aid 911 cellular callers. The technical choices must be supported by the GIS function of the integrated system in order to improve the dispatch center's information flow processes.

The usability test will be conducted to help the dispatch center personnel understand how the interface design will effect the operation. If the proper training occurs for the end users, and the new interface does not impede the dispatching of emergency response personnel by the dispatchers, then the technology should facilitate the locating of 911 cellular callers. The usability testing plan, complete with its pre-test questionnaire, cognitive walkthrough, think aloud observation, and post-test user interface satisfaction questionnaire (Chin, 1998), should generate enough qualitative and quantitative data to support the successful implementation of the CAD/GIS Enhanced 911 Phase II system at the dispatch center. The goal of the usability testing is to make the transition to the new interface design as transparent as possible, improve the ability of the dispatchers to make critical decisions when locating cellular callers in distress, and to provide the employees with relevant information in an efficient and effective interface display. The empirical research derived from this usability testing should provide valuable information that can be applied to dispatch centers nationwide that are implementing Phase II of the Enhanced 911 systems.

USABILITY TEST PLAN

Procedure and Purpose

Before commencement of any usability study consent forms must be obtained for all participants and management personnel within the dispatch center in which you are conducting the research. The purpose of the study along with any potential interview questions, questionnaires, testing methods and consent forms must be submitted for approval. The goals and objectives of the study need to be clearly defined (Norman, 1988). Once the approval has been obtained then the study may proceed. The usability test plan developed for the Enhanced 911 system consists of the items described below.

Pre-test Questionnaire

The pre-test questionnaire will be used to evaluate the CAD/GIS interface design. The participants will be asked to complete a pre-test questionnaire that contains the following information: age, educational level, time employed at the dispatch center, work/shift schedule and previous field of employment. The applicable results from the pre-test questionnaire will be evaluated quantitatively and qualitatively for usability effectiveness (Jordan, 1998).

Cognitive Walkthrough

Four participants will be chosen randomly from the pool of dispatcher participants to conduct an initial cognitive walkthrough of the interface to determine any major problems with the interface design. The purpose of the cognitive walkthrough is to detect any major problems with the interface design before proceeding with the remainder of the usability testing. The dispatchers will be instructed on the procedure for cognitive walkthroughs by the study monitor. After the cognitive walkthrough is completed, and any major problems with the interface are corrected, the total population of the dispatcher participants will be then be allowed to complete the usability testing of the interface design. The cognitive walkthrough will be evaluated qualitatively (Lewis, Polson, Wharton, and Rieman, 1990).

Think Aloud Observation

The usability test will consist of all dispatcher participants using the new interface design for one hour during their regular work shift at the dispatch center. The participants will be given instructions on the procedures for think aloud evaluation, and their responses will be recorded through the use of audiotape or the use of the dispatch center's DBMS which records all calls received. The participants will be encouraged to voice any strengths or weaknesses of the new system, in addition to any questions, concerns, or problems they encounter in performing their routine tasks. The think aloud responses will be evaluated qualitatively. This is to evaluate qualitatively any slowness in the system, distraction caused by the new window in the screen, interruption of work flow, or problems caused by the integration of the new software with existing hardware (Jordan, 1998;Preece, Rogers, and Sharp, 2002).

Interviews

Interviews are expected to last no longer than an hour. The actual length of the interviews will depend on the availability of participants. The interviews will be conducted by one interviewer and will be derived from a script of interview questions that are designed to obtain specific information for suggestions to improve the dispatcher's use of the new system. Study participants may be audio taped during interviews if they grant permission to be taped. If for any reason permission to be audio taped is not granted by the participant the information will be transcribed by the interviewer. The results of the interviews will be utilized to enhance the usability of the system through user design suggestions (Jordan, 1998).

Quantitative Data Collection

The calls will be divided by type, either cellular or land-based call, and then subdivided into four categories: Fire, Law Enforcement, Emergency Medical Services, and Other. During the use of the system the participants will be monitored using the existing DBMS to determine the type, number of calls dispatched, the time to dispatch the call to emergency personnel from the time it was received by the dispatcher, and the elapsed time between the time the call was dispatched until emergency personnel arrive on the scene. The benchmark for success will be if the cellular 911 call dispatching and emergency personnel elapsed times do not exceed the average elapsed times for land-based 911 calls. This will allow for competitive testing to compare the new system to the old system, by comparing the same data types of the both systems. This can be accomplished by obtaining the records of the mean dispatching times for call data from the DBMS for the old CAD system and comparing it with the mean dispatching times for call data of the new CAD/GIS integrated system (Jordan, 1998).

Post-test Questionnaire

After completion of the use of the new interface design, the participants will complete a user satisfaction survey. This survey will analyze the user's experience with the new design. The applicable results from the user satisfaction will also be evaluated quantitatively and qualitatively (Shneiderman, 1998).

CONCLUSION

The importance of conducting usability testing of the implementation of Enhanced 911 Phase II CAD/GIS integrated systems is paramount to the nationwide safety of cellular phone customers. Not only has usability testing demonstrated that it leads to a smoother conversion of systems, but it also enhances the task completion and acceptance of the users. In a situation where the use of a system could mean the difference between a life and death event for the 911 cellular callers, it magnifies the importance of usability research for the proper integration of a system. There are, however, drawbacks to usability testing due to the limited number of calls actually received during the testing period not being a true snapshot of the capacity of the system or its limitations (Shneiderman, 1998). This results in a difficulty in determining how the future usage will actually be. In the case of the emergency response dispatch center the quantitative data is collected with every call received so further evaluation can be completed to determine future usability results.

There is also a limitation in the cellular phone technology because there are two different types of CAD systems receiving 911calls in dispatch centers nationwide. These are network-based systems and handset-based systems (Hatfield, 2002). Since the majority of customers do not have Global Positioning Systems (GPS) capabilities within their cellular phones, and the caller may be in motion, this creates a limitation for pinpointing the caller's exact location particularly with the handset-based receiving systems. Even with these limitations the dispatcher will be able to determine the location of the cellular 911 caller when the call was received and they will not have to overcome the severe information gap they are currently experiencing. When studying human factors in system integration there should be a continuous and iterative maintenance and evaluation process to detect any flaws in the system and correct them. Usability testing methods should establish this process at the 911 dispatch centers so that when the technology is implemented the dispatchers are capable of utilizing it to support their critical tasks of dispatching emergency personnel in the least amount of time.

This study will provide new information to the cellular phone companies, land based telephone companies, CAD system designers, GIS system component designers, and 911 dispatch center personnel to enhance the safety and security of all 911 cellular callers by assembling the pieces of the Enhanced 911 Phase II puzzle that currently exists. The information derived from this study should be applicable to other 911 dispatch centers nationwide by allowing them to seamlessly transition from Phase I to Phase II Enhanced 911 systems by avoiding any delays in the retrieval of 911 cellular caller location information. The research for this study should also assist in the "end-to-end" testing needed for the development of a national set of standardized procedures for compliance testing and certification of wireless Enhanced 911 location systems. The lack of national compliance and certification standards has been noted as a void in the current implementation design of Phase II Enhanced 911systems that needs to be addressed by possibly creating an Enhanced 911 overseeing entity in the Office of Homeland Security (Hatfield, 2002). This research, which is vital to the efficiency and productivity of our homeland security first responders, the 911 dispatchers, is projected to begin in June 2004.

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